PL-5 AAPPS-DPP2019

3rd Asia-Pacific Conference on Plasma Physics, 4-8,11.2019, Hefei, China

Exploration of Nonlinear Compton Scattering between a Laser-Accelerated GeV Electron Beam and a PW Laser

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Thanks to the Nobel prize-winning chirped pulse amplification technique, ultrahigh intensity lasers with peak power over 1 PW have been developed in a number of institutes around the world for the investigations of laser-matter interactions under extreme physical conditions. At Center for Relativistic Laser Science a 20 fs, 4 PW Ti:Sapphire laser has been developed by upgrading one of two petawatt laser beamlines operational since 2012 [1]. With the PW lasers we have investigated strong field physics, especially laser-driven charged particle accelerations [2,3]. By applying the laser wakefield acceleration (LWFA) scheme, we could produce multi-GeV electron beams and we are preparing the experimental demonstration of nonlinear Compton scattering between a GeV electron beam and an ultrahigh intensity laser.

The Compton scattering of a relativistic electron beam with an ultrahigh intensity laser can be a test bench for examining strong field quantum electrodynamics (QED) processes. In this Compton backscattering process, the energy is transferred from a relativistic electron to a laser photon, converting the low energy laser photon into a gamma ray. At CoReLS the production of GeV electrons has been studied with its PW lasers. Using a dual gas jet target, the generation of multi-GeV electron beams was successfully demonstrated [2]. The control of the LWFA process was tested by applying chirped PW laser pulses, and stable 2 GeV electron beams were produced from a He gas cell when driven with positively chirped laser pulses [3]. The generation of high charge multi-GeV electron beams from a He gas cell with the multi-PW laser has been obtained by implementing an ionization injection scheme.

We are investigating Compton scattering from the interaction of a GeV electron beam and another laser beam in the nonlinear regime. For the preparation of nonlinear Compton scattering we are testing several laser targets with different designs for the stable generation of GeV electron beams and examining gamma-ray spectrometers (Fig. 1). Additionally, ultrahigh intensity laser pulses over 10^{22} W/cm^2 has been obtained by controlling the laser wavefront with a set of deformable mirrors and by tightly focusing the laser beam. The investigation of nonlinear Compton scattering between a GeV electron beam and an ultrahigh intensity laser will offer the opportunity to explore strong field QED effects in photon-electron and photon-photon interactions.

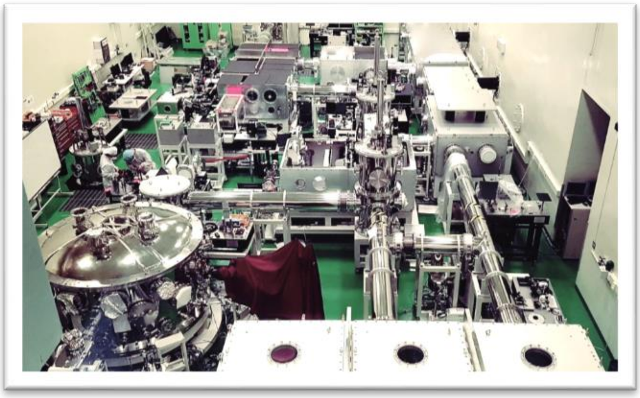

Fig. 1 Photo of the experimental area showing three target chambers including the electron acceleration chamber.

References
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